

EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Aaron Grunberger on 08/25/09 and 09/10/09.

The application has been amended to the claims filed on 04/06/09 as followed:

** Claim 4 has been amended to reflect the following:

4. (Currently Amended) A method of forming a silicon oxide layer, comprising: positioning a substrate in a deposition chamber; and forming a silicon oxide layer by iteratively performing the following steps multiple times:

oxidizing a silicon precursor gas in the deposition chamber at a first temperature to form a sub-layer of the silicon oxide layer;

providing an oxygen-rich environment in the deposition chamber during the oxidization of the silicon precursor gas;

heating the substrate to a second temperature higher than the first temperature to anneal the sub-layer of the silicon oxide layer; and

providing an oxygen-rich environment in the deposition chamber during the heating of the substrate;

wherein:

Art Unit: 1792

the formation of each of the sub-layers formed subsequent to a first one of the sub-layers, the first sub-layer having been formed prior to all of the other of the sub-layers, is directly on a respective previously formed one of the sub-layers;

the substrate is subjected to subsequent processing steps after said silicon oxide layer is formed; and

the second temperature is approximate to the highest processing temperature ~~subsequently applied to the substrate following formation of the silicon oxide layer~~
during said subsequent processing steps.

** Claim 11 has been canceled.

** Claim 16 has been amended to reflect the following:

16. (Currently Amended) A method of forming a microelectromechanical systems (MEMS), comprising:

forming a MEMS structure on a substrate; ~~and~~

thereafter, positioning the substrate in a deposition chamber; and

forming a silicon oxide layer by iteratively performing the following steps multiple times:

oxidizing a silicon precursor gas in the deposition chamber at a first temperature to form a sub-layer of the silicon oxide layer;

providing an oxygen-rich environment in the deposition chamber during the oxidization of the silicon precursor gas; and thereafter,

Art Unit: 1792

heating the substrate to a second temperature higher than the first temperature to anneal the sub-layer of the silicon oxide layer; and

providing an oxygen-rich environment in the deposition chamber during the heating of the substrate; wherein:

the formation of each of the sub-layers formed subsequent to a first one of the sub-layers, the first sub-layer having been formed prior to all of the other of the sub-layers, is directly on a respective previously formed one of the sub-layers;

the substrate is subjected to subsequent processing steps after said silicon oxide layer is formed; and

the second temperature is approximate to the highest processing temperature applied to the substrate during said subsequent processing steps.

** Claim 17 has been canceled.

** Claim 18 has been amended to reflect the following:

18. (Currently Amended) The A method of ~~claim 17~~ forming a microelectromechanical systems (MEMS), further comprising:

forming a MEMS structure on a substrate;

thereafter, positioning the substrate in a deposition chamber;

oxidizing a silicon precursor gas in the deposition chamber at a first temperature to form a silicon oxide layer on the substrate;

providing an oxygen rich-environment in the deposition chamber during the oxidization of the silicon precursor gas;

thereafter, heating the substrate to a second temperature higher than the first temperature to anneal the silicon oxide layer; and

providing an oxygen-rich environment in the deposition chamber during the heating of the substrate.

** Claim 22 has been amended to reflect the following:

22. (Currently Amended) The method of claim ~~46~~ 18, wherein the second temperature is approximate to the highest processing temperature applied to the substrate following the annealing of the silicon oxide layer.

** Claim 24 has been amended to reflect the following:

24. (Currently Amended) The method of claim ~~47~~ 16, wherein the oxygen-rich environment further comprises at least one gas selected from a the group of gases consisting of nitrogen, helium, argon, ozone and steam.

** Claim 29 has been amended to reflect the following:

29. (Currently Amended) The method of claim 16, wherein the silicon precursor gas comprises at least one gas selected from a the group of gases consisting of: tetraethoxysilane (TEOS), silane (Sill4), dichlorosilane (DCS), diethylsilane (DES), and [[/or]] tetramethylcyclotetrasiloxane (TOMCATS).

** Claims 31-40 have been canceled.

** Claim 44 has been amended to reflect the following:

44. (Currently Amended) A method of forming a silicon oxide layer, comprising:
positioning a substrate in a deposition chamber; and forming a silicon oxide layer by
iteratively performing the following steps multiple times:

decomposing a silicon precursor gas in the deposition chamber at a first
temperature to form a sub-layer of the silicon oxide layer;

providing an oxygen-rich environment in the deposition chamber during
the decomposition of the silicon precursor gas;

heating the substrate to a second temperature higher than the first temperature
to anneal the sub-layer of the silicon oxide layer; and

providing an oxygen-rich environment in the deposition chamber during the
heating of the substrate; wherein:

the formation of each of the sub-layers formed subsequent to a first one of the
sub-layers, the first sub-layer having been formed prior to all of the other of the sub-
layers, is directly on a respective previously formed one of the sub-layers;

the substrate is subjected to subsequent processing steps after said silicon oxide
layer is formed; and

the second temperature is approximate to the highest processing temperature subsequently applied to the substrate ~~following formation of the silicon oxide layer~~ during said subsequent processing steps.

** Claim 51 has been amended to reflect the following:

51. (Currently Amended) The ~~[[A]]~~ method of ~~forming a silicon oxide layer~~ claim 44, comprising:

~~positioning a substrate in a deposition chamber; and forming a silicon oxide layer by iteratively performing the following steps multiple times:~~

~~decomposing a silicon precursor gas in the deposition chamber at a first temperature to form a sub-layer of the silicon oxide layer; and~~

~~heating the substrate to a second temperature higher than the first temperature to anneal the sub-layer of the silicon oxide layer; wherein:~~

~~the formation of each of the sub-layers formed subsequent to a first one of the sub-layers, the first sub-layer having been formed prior to all of the other of the sub-layers, is directly on a respective previously formed one of the sub-layers; and~~

~~the silicon oxide layer is formed with a compressive stress, such that following the step of heating the substrate, the silicon oxide layer has very low internal stress.~~

** 57. (NEW) The method of claim 18, wherein the silicon precursor gas is provided at low pressure.

Art Unit: 1792

** 58. (NEW) The method of claim 18, wherein the oxygen-rich environment further comprises at least one gas selected from the group of gases consisting of nitrogen, helium, argon, ozone and steam.

** 59. (NEW) The method of claim 18, wherein the second temperature ranges from 700 to 1200°C.

** 60. (NEW) The method of claim 18, wherein the silicon precursor gas comprises at least one gas selected from the group of gases consisting of: tetraethoxysilane (TEOS), silane (SiH_4), dichlorosilane (DCS), diethylsilane (DES), and tetramethylcyclotetrasiloxane (TOMCATS).

** 61. (NEW) The method of claim 18, wherein the silicon oxide layer is formed with a compressive stress, such that following the step of heating the substrate, the silicon oxide layer has very low internal stress.

** 62. (NEW) The method of claim 18, further comprising:

etching the silicon oxide layer, wherein the etching comprises:

applying a first etching process to the silicon oxide layer which forms an etch residue;

oxidizing the etch residue; and

applying a second etching process to the oxidized etch residue.

Allowable Subject Matter

The following is an examiner's statement of reasons for allowance:

Claims 4, 16 and 44 are distinguished over the prior art of record (Yu in view of Ito) wherein Yu teaches a method of forming a silicon oxide layer, by positioning a substrate in a deposition chamber; and forming a silicon oxide layer by oxidizing a silicon precursor gas in the deposition chamber at a first temperature to form a silicon oxide layer and providing an oxygen-rich environment in the deposition chamber during the oxidation of the silicon precursor gas [col 9, ln 45-66], heating the substrate to a second temperature higher than the first temperature to anneal the sub-layer of the silicon oxide layer; and providing an oxygen-rich environment in the deposition chamber during the heating of the substrate [col 10, ln 40-55], and wherein Ito teaches forming a first silicon oxide layer on a substrate, and forming a second silicon oxide layer on the first silicon oxide layer (the formation of each of the sub-layers formed subsequent to first one of the sub-layers, the first sub-layer having been formed prior to all of the other of the sub-layers, is directly on a respective previous formed one of the sub-layers) [col 4, ln 49-67; col 5, ln 1-10; Fig. 4C-D]; however, Ito fails to teach heat treating (annealing) the substrate at a second temperature higher than the first temperature of the oxidizing step and providing an oxygen-rich environment during the heat treating. Furthermore, Yu in view of Ito fails to teach the substrate is subjected to subsequent processing steps after said silicon oxide layer is formed; and the second temperature is

Art Unit: 1792

approximate to the highest processing temperature applied to the substrate during said subsequent processing steps.

In addition, US 4278705 (Agraz) and US 5994756 (Umezawa) is cited here for further reasons for allowance.

Agraz teaches a method for forming a silicon oxide layer by oxidizing a silicon substrate to form a sub-layer and annealing the sub-layer in an oxygen-rich environment, and iteratively performing the above mentioned steps to collectively form a silicon oxide layer on the substrate [col 3, ln 15-45], but fails to teach oxidizing a silicon precursor gas in the deposition chamber at a first temperature to form the sub-layer, and annealing the substrate to a second temperature higher than the first temperature, and subjecting the substrate to subsequent processing steps after said silicon oxide layer is formed; wherein the second temperature is approximate to the highest processing temperature applied to the substrate during said subsequent processing steps.

Umezawa teaches forming a silicon oxide film on a substrate [abstract] by oxidizing a silicon precursor gas in the deposition chamber at a first temperature to form a silicon oxide layer, and providing an oxygen-rich environment in the deposition chamber during the oxidization of the silicon precursor gas; heating the substrate to a second temperature higher than the first temperature to anneal the silicon oxide layer; and providing an oxygen-rich environment in the deposition chamber during the heating of the substrate [col 5, ln 40-67-col 6, ln 1-40], but fails to teach (iteratively performing the steps to allow the formation of sub-layers of the silicon oxide layers formed

Art Unit: 1792

subsequent to a first one of the sub-layers, the first sub-layer having been formed prior to all of the other of the sub-layers, is directly on a respective previously formed one of the sub-layers; the substrate is subjected to a subsequent processing steps after said silicon oxide layer is formed; and the second temperature is approximate to the highest processing temperature applied to the substrate during said subsequent processing steps.

The prior art of record neither teaches nor suggests the combination of limitations recited in the instant claims.

Claims 16 and 18 are distinguished over the prior art of record (Reichenbach) wherein Reichenbach teaches forming a MEMS structure on a substrate and depositing silicon oxide onto the substrate [abstract], wherein the silicon oxide is of a porous grade [0044], but fails to teach specifically for claim 16, iteratively forming sub-layers of the silicon oxide layer by oxidizing a silicon precursor gas in an oxygen rich environment at a first temperature, annealing the sub-layers to a second temperature higher than the first temperature in an oxygen-rich environment, and subjecting the substrate to subsequent processing steps after said silicon oxide layer is formed; and the second temperature is approximate to the highest processing temperature applied to the substrate during said subsequent processing steps. In regards to claim 18, although, Reichenbach appears to teach providing a second temperature higher than the first temperature for annealing the polysilicon layer on top of the oxide layer, there is no suggestion to provide an oxygen-rich environment in the deposition chamber during the

Art Unit: 1792

heating of the substrate (which would lead to undesirable results to the polysilicon layer). Moreover, such that Reichenbach appears to avoid compaction of the highly porous oxide layer, thereby suggesting it would be desirable to keep the temperature as low as possible for further heating steps.

In addition, US 2002/0094388 (Fonash) is cited here for further reasons for allowance.

Fonash teaches forming a silicon oxide layer on a substrate and annealing the layer [abstract], but fails to teach specifically for claim 16, heating the substrate to a second temperature higher than the first temperature to anneal the oxide layer; and providing an oxygen-rich environment in the deposition chamber during the heating of the substrate; wherein the silicon oxide layer is produced by iteratively forming sub-layers in the formation of each of the sub-layers formed subsequent to the first one of the sub-layers, the first sub-layer having been formed prior to all of the other of the sub-layers, is directly on a respective previously formed one of the sub-layers; and subjecting the substrate to subsequent processing steps after said silicon oxide layer is formed; and the second temperature is approximate to the highest processing temperature applied to the substrate during said subsequent processing steps. In regards to claim 18, Fonash fails to teach providing an oxygen-rich environment in the deposition chamber during the heating of the substrate.

The prior art of record neither teaches nor suggests the combination of limitations recited in the instant claims.

Art Unit: 1792

Since the prior art of record neither teaches nor suggests the combination of limitations recited in the instant claims, one skilled in the art would not have been motivated to perform the claimed process.

Conclusion

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MANDY C. LOUIE whose telephone number is (571)270-5353. The examiner can normally be reached on Monday to Friday, 7:30AM - 5:00PM EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Timothy Meeks can be reached on (571)272-1423. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Art Unit: 1792

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/M. C. L./
Examiner, Art Unit 1792

/Timothy H Meeks/
Supervisory Patent Examiner, Art Unit 1792